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A Comparison between Selected Pre-Final Decision and Completed Superfund Sites in EPA Region 4

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A Comparison between Selected Pre-Final Decision and Completed Superfund Sites in EPA Region 4

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I
INTRODUCTION

1.1 Background

Environmental Justice according to the EPA is defined as "the fair treatment and meaningful involvement of all people regardless of race, color, national origin, or income with respect to the development, implementation, and enforcement of environmental laws, regulations, and policies" ("Environmental Justice," 2014). Since President Bill Clinton issued an executive order in 1994 that requires "Federal Actions to Address Environmental Justice in Minority Populations and Low-Income Populations" (Nweke et al., 2011), the Environmental Protection Agency (EPA) is mandated to address environmental equity in minority and low-income populations. Although the1994 Executive Order requires assessments of environmental justice, there is no consensus amongst regulators how to quantifiably assess the provision administration of environmental justice (Waller, Louis, & Carlin, 1999).

1.2 Purpose of Study

The purpose of this study is to determine if the populations living within close proximity to Post-Record of Decision (ROD) Superfund sites that have completed clean-up operations are similar to those living within close proximity to a Pre-ROD Superfund site in EPA Region 4.

1.3 Research Questions

1) Is the population living within one mile of selected Pre-Record of Decision (ROD) Superfund sites different than the total population living with matched Superfund sites where clean-up have been completed when comparing race/ethnicity and income levels?

2) For each State in EPA Region 4, is the population living within a one-mile radius selected Pre-ROD Superfund sites different than the population living within a one-mile radius of selected Post-ROD Superfund sites?

CHAPTER II
REVIEW OF THE LITERATURE

Superfund Sites and the Process of becoming listed on the National Priorities List (NPL):

Superfund refers to the Environmental Protection Agency (EPA) program that cleans up hazardous waste sites as well as the fund that originally financed the clean up efforts (US EPA, Basic Information). In 1980, President Carter and the U.S. Congress established the Comprehensive Environmental Response Compensation and Liability Act (CERCLA) (O'Neil, 2007). As part of CERCLA, the EPA locates and prioritizes the cleanup of hazardous sites across the United States. The most hazardous sites can be placed on the National Priorities List (NPL). Through placement on this list, the site is eligible for funding for remediation through the Superfund that was originally funded by a tax on chemical and petroleum industries, however it is now funded through a combination of charging the responsible parties when possible and using a yearly budget (O'Neil, 2007).

The process of designating a site to be eligible for funds through the Superfund is lengthy and complicated. It begins when a potential site is reported to the EPA through a person,

community, or other federal agency. Once a site has been directed towards the EPA, a preliminary site assessment and investigation take place. During the preliminary investigation, the EPA collects information, both historical and current, to determine whether or not there is a potential threat to human health as well as the environment. During the site investigation, water, soil, and air samples are collected to determine what hazardous materials are present and whether or not the levels are a threat to human health and the environment ("The Superfund Process"). During these steps, the EPA comes up with a numerical value called the hazard ranking system (HRS) score. The HRS score does not mean that a higher score gets fast tracked for cleanup, it is simply a tool that helps determine which sites should be placed on the NPL.

Subsequent to the initial investigation, the site may be placed on the NPL. There are three mechanisms through which a proposed site could be placed on the NPL: 1) It can be designated to the NPL using the HRS score. 2) States and territories can identify one priority site regardless of the score. 3) The Agency for Toxic Substances and Disease Registry (ATSDR) issues a health advisory recommending that people are moved away from the site, EPA determines a substantial threat the public health, and EPA determines that it will cost less to do the remediation through listing it on the NPL rather as an emergency response ("National Priorities List (NPL)," 2012).

After the site becomes listed on the NPL, a remedial investigation and feasibility study (RI/FS) takes place. During this step, the magnitude of the contamination, cleanup methods and cost are determined. The EPA creates a proposed plan for the cleanup of the site ("The Superfund Process"). Following the RI/FS phase, a Record of Decision (ROD) is created. This is a public document that explains which remediation alternatives will be used to cleanup the site ("Record Of Decision," 2014).

After the publication of the ROD, the Superfund sites enter the remedial design and action phases. During the remedial design phase, the EPA finalizes the remediation plan for the site deciding what technologies will be utilized during the cleanup process ("The Superfund Process,"). During remedial action, the remediation plan is implemented to cleanup the Superfund site. The Superfund site will enter the construction complete phase if the physical construction has been completed for the site-even if the cleanup levels have not been met, the EPA decides when remediation actions do not include further construction, or the site qualifies for deletion from the NPL.

The EPA wants to ensure that human health and the environment are protected from the hazardous materials of the Superfund sites, so a post construction completion step is included in the Superfund process. During this step, EPA continues to monitor the long-term cleanup technologies to make sure they are working. The EPA also monitors that the cleanup of the site remains effective and can implement new cleanup technologies if it is necessary ("The Superfund Process,").

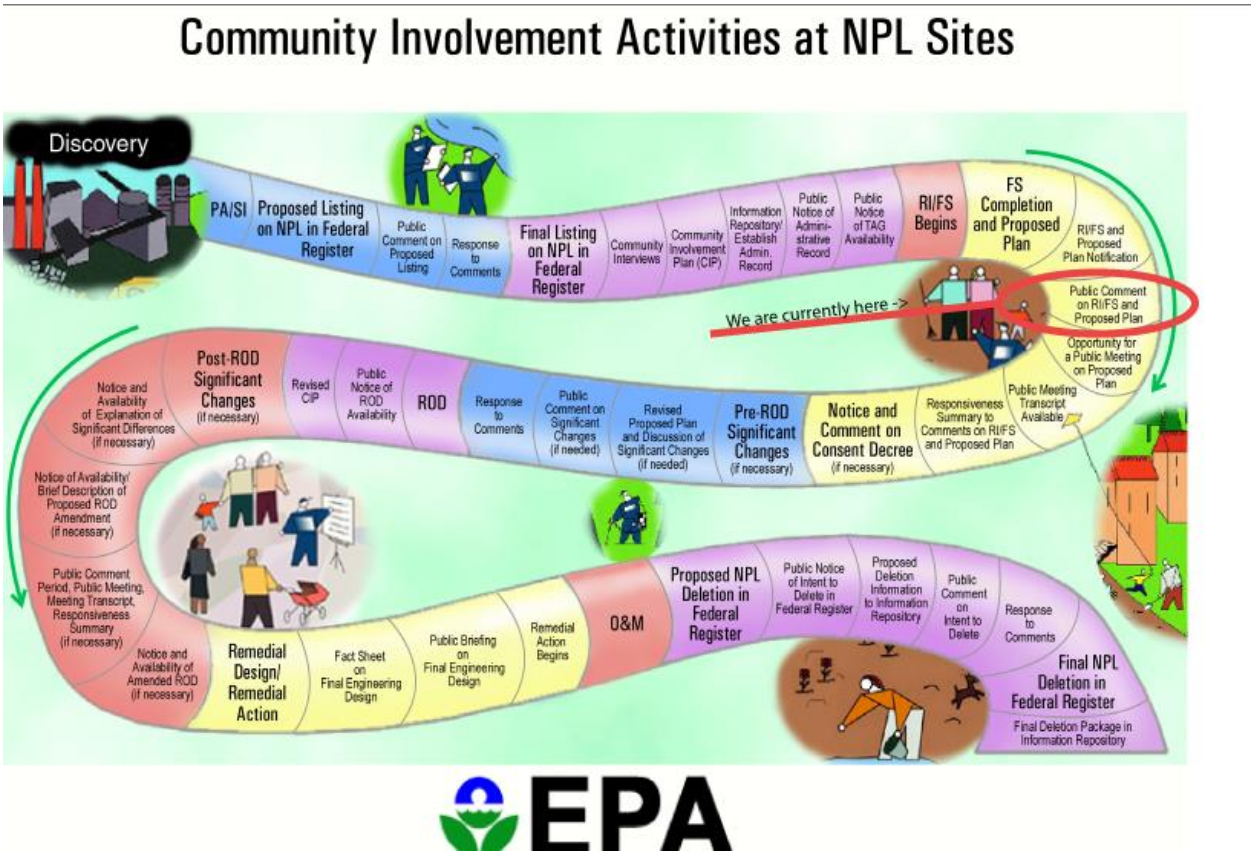
As part of CERCLA, a five-year review takes place that also helps to determine if the implemented measures remain effective ("Five-Year Reviews, EPA). The five-year reviews take place five years after a response action and then are repeated every five years following the first review. The EPA or other agencies can perform the five-year review, but the EPA ultimately remains responsible for determining if the remedies remain protective ("Five-Year Reviews, EPA).

The last step in the process is that the EPA may delete a site from the NPL if it is determined that no further action is needed to protect the environment and human health. In

order for the Superfund site to be deleted from the NPL, one of the following must be met: it has been determined that the responsible parties or other parties have implemented response actions that were required for cleanup, all of the appropriate Superfund financed remediation actions have been implemented, or a RI/FS shows that there is no threat to human health or the environment ("How Sites are Deleted from the NPL," 2014).

Below is a diagram that depicts the process of becoming a Superfund site listed on the NPL to the end of the process where the NPL is removed. It should be noted, however, that time-critical remedial actions or interim actions that are necessary to protect human health and the environment may take place at any time along the process, including prior to proposed listing.

Figure 1: Diagram showing the Steps of becoming a Superfund Site on NPL and Cleanup Activities



("Our Links | Protect Gainesville's Citizens,"http://protectgainesville.org/files/2010/07/CleanupProcess.jpg)

EPA Region 4:

The EPA is comprised of 10 regions based on geographical location. EPA Region 4 is the Southeast region that serves Alabama, Florida, Georgia, Kentucky, Mississippi, North Carolina, South Carolina, and Tennessee. ("About EPA Region 4 (Southeast)," 2014). EPA Region 4 offices have multiple divisions that focus on specific components of the environment such as water protection, Superfund, and Resource Conservation and Recovery. In EPA Region 4, the Superfund division is responsible for protecting public health and the environment through cleanup of hazardous waste sites. The Superfund division addresses sites listed on the NPL as well as emergency sites that require immediate action("Organization Chart for EPA's Region 4 Office," 2014).

In their effort to address environmental justice issues, Region 4 focuses on integrating the communities in decision-making and procedures. To do this, the region works with state officials, tribes, as well as affected communities in the implementation and policy making that helps to protect the environmental as well as the public health of the community ("Region 4: Environmental Justice," 2014). Although Region 4 does have a specific focus on environmental justice, there is not a pre-specified procedure for how to assess environmental justice efforts across the region.

Environmental Justice and the EPA:

In the early 1980s, environmental justice became a focus in the United States because minority and low-income populations began to raise their voices against having environmental hazards in their neighborhoods (O'Neil, 2007). During this time period, researchers began to analyze the population makeup of communities near hazardous waste sites and found that they were often minorities and poor (O'Neil, 2007). It has been hypothesized that lower

socioeconomic classes and minorities carry a heavier burden from environmental hazards due to the lack of power (O'Neil, 2007). With substantial evidence suggesting that there was a problem, lobbyists began to push for an executive order that would force federal agencies to focus on the problem (Walker, 2012). In 1994, President Bill Clinton signed Executive Order 12898 that states:

> To the greatest extent practicable and permitted by law…each Federal agency shall make achieving environmental justice part of its mission by identifying and addressing, as appropriate, disproportionately high and adverse human health or environmental effects of its programs, policies, and activities on minority populations and low-income populations in the United States ("EPA Needs to Perform Environmental Justice Reviews.," 2006)

Although the order was passed back in 1994, there has been much debate on how the order is interpreted and put into action across federal agencies, especially in the EPA.

Each region in the EPA identifies its own approach to implementing environmental justice practices. As a result of the ability for each region to implement EJ activities differently, in 2003 the Office of the Inspector General (OIG) conducted an evaluation regarding implementation of EJ and found that the EPA offices do not have a clear method on how to conduct environmental justice reviews. It was also determined that management often times does not require a review as part of a project which makes it less likely to have an environmental justice review component (Walker, 2012).

Office of Enforcement and Compliance Assurance (OECA) and Office of Environmental Justice (OEJ) Environmental Justice Review Process:

Even though there is not a specific method for an environmental justice review across all EPA regions, the Office of Enforcement and Compliance Assessment (OECA) and Office of Environmental Justice (OEJ) have created an environmental justice review process. The general process provided includes six steps:

1) Determine the affected subpopulations which would include low-income, minorities, and/or tribal populations
2) Communicate openly with the affected subpopulations
3) Determine the geographic boundaries of the affected area and identify the demographic composition of the population in the geographic boundary.
4) Analyze the environmental and health effects and locate potential exposures
5) Develop remediation actions to remove the environmental and health exposures with ample input from the affected community
6) Calculate immediate and long-term health effects of the affected community ("Environmental Justice Analysis," 2014)

Although there is not a specific guideline to follow in order to analyze environmental justice, regional offices across the United States are working to promote environmental equity. In 2004, OEJ released a report that highlighted regional programs and grants that for each region. Even though each region has a commitment to addressing environmental justice issues, the lack of federal funding for these programs as well as inconsistencies throughout the nation, environmental injustice remains a problem, especially for Superfund sites (O'Neil, 2007).

Environmental Justice and Superfund Sites:

There is a plethora of research on environmental burdens and environmental justice, however fewer studies exist that characterizes Superfund remediation and its relationship with

environmental justice (O'Neil, 2007). O'Neil (2007) hypothesized that the resources to clean up Superfund sites may not be evenly distributed throughout the population with the minority and low-income populations being grossly under-represented in the allocation of funds. There have been multiple studies that attempt to determine whether minorities and low-income populations are more likely to live near NPL sites or if the population around the sites is wealthier (Zimmerman, 1993; O'Neal 2007; Lavelle & Coyle, 1992; Hird, 1993). Zimmerman (1993) found that minorities and poor population are found in larger percentages near a NPL site. However, this study did not include rural sites and the results could have been biased based on the fact that urban populations often times are comprised more often or minorities and poorer populations (O'Neil, 2007).

Lavelle and Coyle (1992) studied Superfund sites at the zip code-level and found that sites located closer to poorer neighborhoods took longer to be listed on the NPL and thus had longer cleanup duration. Hird (1993) studied Superfund sites at the national and county level and concluded the wealthy were more likely to be represented in the Superfund cleanup program. It was noted in this study that minorities are more likely to live in close proximity to hazardous sites, however these sites are less likely to be listed on the NPL (Hird, 1993). Some researchers suggest that when a wealthier population is more likely to live in proximity to a hazardous site listed on the NPL, they are more likely to benefit from the resources from the federal government (O'Neal, 2007). On the other hand, some researchers suggest that minorities and poorer populations are experiencing environmental injustice since a larger proportion is living in close proximity to the NPL sites (Zimmerman, 1993).

In 1987, the United Church of Christ did a study that analyzed the racial and socioeconomic characteristics of the population living in communities surrounding hazardous

waste sites ("Toxic Waste and Race", 1987). They aimed to determine whether there was a relationship between the racial composition of a population and the location of a hazardous waste site. In this study, the 5-digit zip code was used to define the community of interest comparing communities with hazardous waste sites to those without ("Toxic Waste and Race", 1987). What they found was that there was a higher percentage of minorities in communities with hazardous waste sites in comparison to those without. It was also determined that in communities with one hazardous waste site, mean percentage of minorities was double than the communities without the hazardous sites. In communities where there was more than 1 hazardous waste site, the mean percentage of minorities was almost tripled than the communities without a hazardous site. Overall, "Toxic Waste and Race", (1987) found that race is one of the best predictors of hazardous waste sites.

In 2008, a new report was created that gave an update to the 1987 "Toxic Waste and Race" findings. In this analysis 2000 Census data were used as well as an updated list of hazardous waste sites to see if there were similar findings (Bullard, Mohai, Saha, & Wright, 2008). What they found was that there were still significant racial and socioeconomic disparities in the communities surrounding the hazardous waste sites. They actually determined that, based on using 2000 Census data, minorities were more concentrated near hazardous facilities than what was found in 1987 (Bullard et. al., 2008). Bullard et. al., 2008 also looked at state disparities comparing the minority population in host areas versus non-host areas. What they found was that of the 44 states with hazardous sites 90% of them have a higher percentage of minorities in areas containing a hazardous sites, also referred to as host areas, in comparison to non-host areas. The ten states with the largest disproportions include the following: California,

Nevada, Illinois, Alabama, Michigan, Tennessee, Washington, Arkansas, Kentucky, and Kansas (Bullard et. al., 2008).

Environmental Justice Assessments for Superfund Sites:

Having a definitive method to evaluate environmental justice across the EPA would likely increase evaluations of the programs and policies and help guide assessment of these programs and policies to examine the overall impact effect on environmental justice. However, there is much debate on what this evaluation method should consist of, especially when evaluating hazardous sites (Walker, 2012). When attempting to examine environmental justice and Superfund sites, multiple issues arise. One important consideration is how to quantitatively examine populations near sites on the NPL. For example, some researchers determine the population make-up within a defined proximity to the Superfund site (Waller et al, 1999). Research has also been conducted looking at the length of time for a hazardous site to be listed on the NPL and determining if minorities and poor populations have longer wait times (Burda & Harding, 2013). Determining the appropriate way to assess and quantify environmental justice is a difficult task, but having nationally recognized methodology would help to fulfill President Clinton's executive order.

Waller et al. (1999) , in their examination of EJ and spatial inequalities identify three key variables to consider:

a) the exposure to an environmental pollutant (or pollutants),

b) demographically defined subgroups of the population subject to potentially increased risk,

c) the health status of the populations.

Often times, geographic information systems (GIS) are a useful tool for assessment of environmental justice because it can provide exposure, population, and health data for the site that is being analyzed. First, a source of hazardous exposure is identified. Second, a "buffer" is created around the site using the GIS mapping tool. This buffer is typically a specific distance from the exposure source. It is assumed that those living within the buffer are 'exposed' to the hazard while those outside the buffer are 'unexposed'. Actual exposure to environmental contaminants may or may not occur. Third, census data is linked to the population within the defined buffer around the hazardous site. Using the census data, the population can be broken down into subgroups such as racial or income level (Waller et al., 1999).

There is another analytical method to assessing environmental justice, which is referred to as the statistical approach that often times consider parametric models of disease risk. Health and demographic data is used in these models, and when available, exposure data is also used (Waller et al., 1999). Although these two methods are concepts often times used to assess environmental justice, both methods have weaknesses. The first method using GIS mapping, called the proximity-based method, uses the distance from the hazardous site and makes it a dichotomous variable. Making living within a proximity to the superfund site a dichotomous variable does not take into consideration that exposure to the hazard may decrease with an increase in distance from the site. Another problem with the proximity-based method is that changing the 'buffer' distance will change the results (Waller et al., 1999).

Using the statistical approach to assess environmental justice is called risk-based assessment. One problem that exists for this method is the availability of data. Because of confidentiality issues, individual data is often times not available; instead aggregate data is used looking at census-tracts of different defined districts. Because aggregate data is used, 'ecological

fallacy' is often times a problem when using the risk-based assessment. As discussed, both basic approaches to assess environmental justice of a hazardous site are not perfect. In order to determine what method would be best to use as a standard procedure across the EPA, a quantitative definition needs to be determined. With the current EPA definition of environmental justice as "the fair treatment and meaningful involvement of all people regardless of race, color, national origin, or income with respect to the development, implementation, and enforcement of environmental laws, regulations, and policies" ("Environmental Justice," 2014), a proximity-based assessment seems more appropriate to determine the subgroups in proximity to the Superfund Sites.

The following thesis aims to quantify the potential environmental justice disparities of EPA Region 4 Superfund sites. In order to do so, a proximity-based approach is used to quantify the subgroups living with a 1-mile radius of Superfund sites. However, a statistical approach is used to compare the population of sites that are still in the process of being cleaned to sites where construction is either completed or the sites have been deleted from the NPL. The null hypothesis is that the selected Superfund sites with RODs and completed clean-up activities and Pre-ROD Superfund sites will have the same populations. Based on the literature review, it is hypothesized that the populations around Superfund sites that are Pre-ROD in Region 4 will be different with a larger proportion of minorities and low-income inhabitants in comparison to Superfund sites in Region 4 where the clean-up activities have been completed.

Chapter III

METHODOLOGY

3.1 Data Sources

The Superfund sites of interest were those that were Pre-ROD as well as sites that had a projected ROD date. This means that these sites have not reached a formal decision on final actions that may be necessary. However, it is important to note that time critical actions and/or interim actions may have been undertaken to protect human health and the environment, or to stabilize the contamination until a final action can be selected in the Feasibility Study. The list of Superfund sites that are considered Pre-ROD and have a projected date of ROD was found using the Superfund Enterprise Management Systems (SEMS) database. From the database, there are 38 Superfund sites that fell into this category across EPA Region 4. These 38 sites were matched with Superfund sites that have completed RODs and where the prescribed clean-up activities have been completed. For the simplicity of this project, these sites are referred to as Post-ROD sites. The Post-ROD and Pre-ROD Superfund sites were matched based on location, attempting to make the distance between the two sites less than 50 miles. However, due to the random location of these sites, there were sometimes no ROD sites within that small of a distance, so the closest site was chosen for the purpose of this project.

All Superfund sites have a latitude and longitude coordinates that give the specific location of the site. Using these coordinates, the sites were plotted using the EPA ESRI Community analyst software. A 1-mile radius from that point was plotted in the program. For the purposes of this project, it was assumed that a 1-mile radius extended beyond the boundaries of the site into the surrounding communities. Based on the 1-mile radius, a report was generated using the 2010 Census data that was titled “Population Demographics”. The report included

information regarding the race/ethnicity, age, and income for the population living within the 1-mile of the Superfund site of interest. The reports generated data from the 2010 Census for the race/ethnicity and age categories as well as included the projected values for the years 2013 and 2016, however; for income, only the projected values for 2013 and 2016 were included. This project utilizes the Census 2010 data for age and race/ethnicity but uses the projected values for income levels for the year 2013.

3.2 Study Population

The population used in this study was the populations living with the 1-mile radius of the chosen Superfund sites based on their ROD status. The demographics of the l-mile radius population for Post-ROD sites were compared to those of Pre-ROD sites for each matched pair. The information was also grouped by state, focused on the eight states of interest that are part of EPA Region 4: Alabama, Florida, Georgia, Kentucky, Mississippi, North Carolina, South Carolina, and Tennessee.

3.3 Study Measures

To determine if there was a difference between the populations, the variables examined included race/ethnicity and income levels. The race/ethnicity data was pulled from the Census 2010 data and the income data was the projected 2013 data based off of what was gathered in the 2010 census. The categories for the race/ethnicity included white, black, American Indian, Asian, Pacific Islander, some other race, two or more races, and Hispanic origin (any race). The income levels were broken into the following categories: <$15,000, $15,000-$24,999, $25,000-$34,999, $35,000-$49,999, $50,000-$74,999, $75,000-$99,999, $100,000-$149,999, $150,000-$199,999, $200,000+.

3.4 Analysis

Once population demographics were gathered, statistical analysis was performed to determine if the characteristics of the population living within close proximity to post-ROD Superfund sites were different than the population living within close proximity to Pre-ROD Superfund sites in EPA Region 4. These comparisons were made using chi-square analysis using SPSS software. First, a comparison was performed examining populations for all Superfund sites of interest by obtaining a chi-square value and determining if it was statistically significant at an the $\alpha=0.05$ level. Next, a similar comparison was performed and examined by state. The null hypothesis is that the population within a 1-mile radius of the remediated sites would be the same as the population within a 1-mile radius of the nonremediated sites. The alternative hypothesis is that the populations would be different, which was determined based on a statistically significant at $\alpha=0.05$.

Chapter IV

RESULTS

4.1 Comparing Race/Ethnicity and Income Across all Selected Superfund Sites in EPA Region 4

Each of the states had a different number of sites that were included in the study. Alabama had 2 Pre-ROD sites and 2 post-Rod sites used for analysis. Florida had 10 Pre-ROD sites and 8 post-ROD sites. Georgia had 4 Pre-ROD sites and 3 post-RODsites. There was only 1 post-ROD site and 1 Pre-ROD site in Kentucky, but the population was too low to do a comparison between these matched sites based on the necessity for each category to be over 5 in a chi-square calculation, therefore there is no state comparison for Kentucky. However, the population values

were included in total calculation across all of Region 4. For Mississippi, there were 3 Pre-ROD sites and 2 post-ROD sites. North Carolina had 11 Pre-ROD sites and 8 remediated sites. South Carolina had 3 Pre-ROD sites and 3 post-ROD sites. Lastly, Tennessee had 3 Pre-ROD sites and 3 post-ROD sites.

When comparing the total populations of the selected Pre-ROD Superfund sites and comparing it to the matched post-ROD Superfund sites across EPA Region 4, there were a total of 37 Pre-ROD Superfund sites that had a projected ROD date and these sites were matched with 31 post-ROD Superfund sites. The total population for the overall comparison of the race and ethnicity was 124,847 people within the post-ROD sites and 184,541 people within the Pre-ROD sites. The race/ethnicity was broken into 8 categories: white, black, American Indian, Asian, Pacific Islander, some other race, two or more races, and Hispanic origin (any race). The total population broken down by the category of race/ethnicity for the selected superfund sites for each category is presented in Table 1.

Table 1: Total population breakdown of Race/Ethnicity Living within 1-mile radius of select Pre-ROD Superfund Sites and matched Post-ROD Superfund sites in EPA Region 4

	Pre-ROD Sites n=184,541 (%)	**Post-ROD Sites n=124,847 (%)**
White	62,662 (34.0)	46,877 (37.5)
Black	84,190 (45.6)	47,682 (38.2)
American Indian	721 (0.4)	396 (0.3)
Asian	1745 (0.9)	2,364 (1.9)
Pacific Islander	76 (0.0)	95 (0.1)

Some other Race	7,779 (4.2)	3,967 (3.2)
Two or more Races	3,766 (2.0)	2,548 (2.0)
Hispanic Origin (any race)	23,602 (12.8)	20,918 (16.8)

A chi-square analysis was done using the populations shown above in Table 1. The Pearson Chi-Square value calculated was 2,791.976 with df=7. The p-value was determined to be <0.01 which is considered statistically significant difference in race and ethnicity for the population surrounding these sites suggesting statistically significant differences in proportions race and ethnicity when comparing the two groups of Superfund sites.

A comparison was done comparing the overall population for the selected sites to determine if there was a difference between the populations based on income levels. For comparison of the populations based on income levels, there were a total of 37 pre-ROD Superfund sites and 31 matched post-ROD Superfund sites. The income levels were broken down based on the following categories: <$15,000, $15,000-$24,999, $25,000-$34,999, $35,000-$49,999, $50,000-$74,999, $75,000-$99,999, $100,000-$149,999, $150,000-$199,999, and $200,000+. The total population broken down by the category income for the selected superfund sites for each category is presented in Table 2.

Table 2: Total population breakdown based on Income Level Living within 1-mile radius of select Pre-ROD Superfund Sites and matched Post-ROD Superfund sites in EPA Region 4

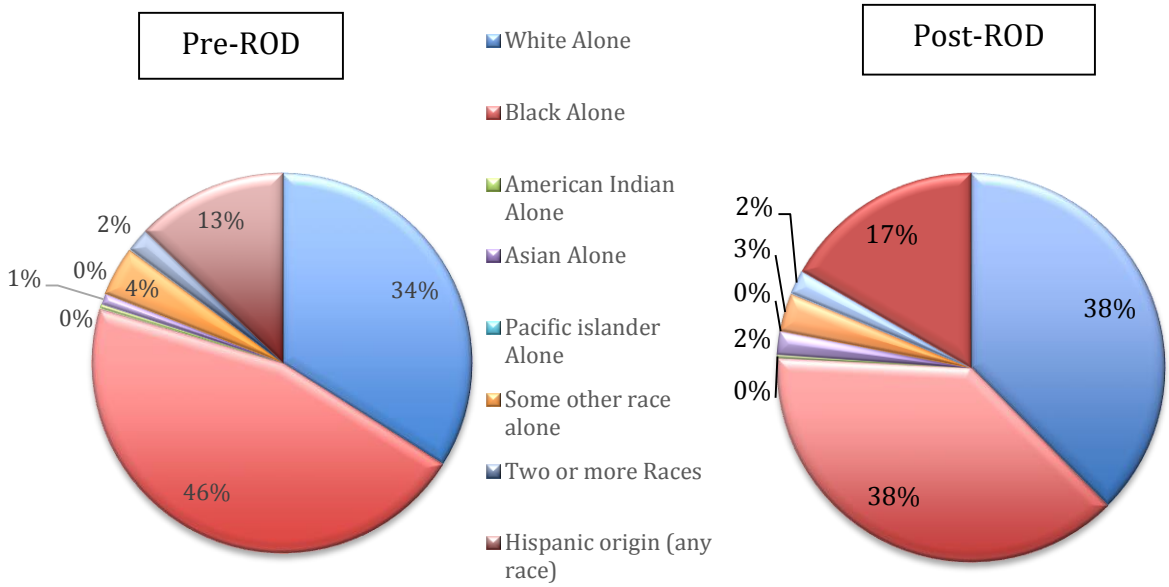
	Pre-ROD Sites n=62,575 (%)	**Post-ROD n=39,756 (%)**
<$15,000	17,451 (27.9)	8,893 (22.4)
$15,000-$24,999	11,529 (18.4)	6,580 (16.6)

$25,000-$34,999	8,613 (13.8)	4,797 (12.1)
$35,000-$49,999	8,936 (14.3)	6,013 (15.1)
$50,000-$74,999	8,560 (13.7)	7,081 (17.8)
$75,000-$99,999	3,499 (5.6)	3,093 (7.8)
$100,000-$149,999	2,864 (4.6)	2012 (5.1)
$150,000-$199,999	609 (1.0)	661 (1.7)
$200,000+	514 (0.8)	626 (1.6)

A chi-square analysis was done using the populations shown above in Table 2. The Pearson Chi-Square value calculated was 1,082.285 with df=8. The p-value was determined to be <0.01, which is considered statistically significant difference in income level for the population surrounding these sites.

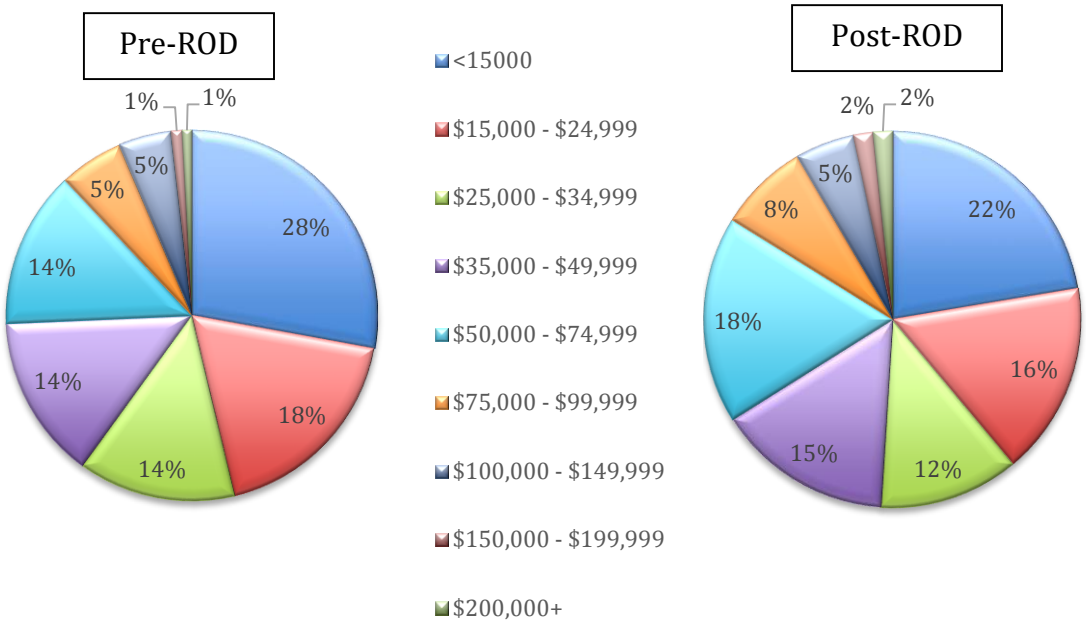
Based on the statistical analysis comparing the selected Pre-ROD sites to the Post-ROD sites across EPA Region 4, the chi-square analyses were statistically significant. Although all of the chi-square values were statistically significant, the proportions in Table 1 and 2 show that the two populations were more similar that the analysis reveals. In order to get a better understanding, the proportions for each comparison were plotted using a pie chart to visually show the breakdown of the race/ethnicity levels and income levels. Figure 2 portrays the proportions of race/ethnicity for the Pre-ROD sites and remediated Superfund sites across the states in EPA Region 4. Figure 3 portrays the income proportions for the Pre-ROD and Post-ROD Superfund site populations across the states in EPA Region 4.

Figure 2: Race/Ethnicity Proportions for Selected Pre-ROD Superfund Sites and Post-ROD Superfund Sites Across all States in EPA Region 4



Visually analyzing the breakdown of the race/ethnicity for the population shows that there is a slight difference between the Pre-ROD and Post-ROD populations, which is visually represented in the pie charts. For example, in the selected Pre-ROD superfund sites for the study, the proportion of blacks living within a 1-mile radius is 46%. In comparison, that of the post-ROD Superfund sites is 38%. Overall, the minority proportion was slightly higher in the Pre-ROD selected Superfund Sites. The white proportion for the Pre-ROD sites was 34% in comparison to 38% in the Post-ROD sites which reveals there is a slightly higher proportion of minorities in the Pre-ROD sites. The income proportions for the income levels were also plotted in pie charts. Figure 3 portrays the income proportions for the selected Superfund sites in the study.

Figure 3: Income Level Percentages for Selected Pre-ROD Superfund Sites and Post-ROD Superfund Sites Across all States in EPA Region 4



Visually analyzing the results for the populations' income levels shows that a larger proportion of the population living within a 1-mile radius of the selected Pre-ROD sites has an income <$15,000 with 28% living in close proximity to the Pre-ROD sites and 22% living within close proximity to the post-ROD sites. Overall, the selected Pre-ROD Superfund sites have a slightly larger proportion of minority people as well has more people in a lower income bracket.

In addition to analyzing the total populations across all states in EPA Region 4, analyses were completed for each state to compare the proportions of race/ethnicity and income for selected Pre-ROD and Post-ROD Superfund sites at the state level. The results for race/ethnicity are presented in Table 3 and the results for income are presented in Table 4.

4.2 Comparing Race/Ethnicity and Income for Select Superfund sites in each State across EPA Region 4

For each state, the race/ethnicity proportions were found for populations living in close proximity to Pre-ROD Superfund sites and Post-ROD Superfund sites. These data are presented in Table 3 with a numerical count of the population and the proportion. Also, a Chi-square analysis was done for each state to determine if the populations were statistically different. Table 4 presents the data for income proportions for the two categories of Superfund sites across the States in EPA Region 4. A chi-square value was also calculated for each state using this data. Subsequent sections discuss the findings for each state.

Table 3: State population breakdown of Race/Ethnicity Living within 1-mile radius of select Pre-ROD Superfund Sites and matched Post-ROD Superfund sites in EPA Region 4

		White	Black	American Indian	Asian	Pacific Islander	Some other Race	Two or more Races	Hispanic Origin (any race)	Chi-Square P Values
Alabama	Pre-ROD n=2 (%)	560 (16.7)	2,593 (77.1)	6 (0.2)	7 (0.3)	0 (0.0)	54 (1.6)	32 (1.0)	109 (3.2)	<0.01
	Post-ROD n=2 (%)	2,200 (79.7)	358 (13.0)	9 (0.3)	9 (0.3)	1 (0.0)	55 (2.0)	19 (0.7)	108 (3.9)	
Florida	Pre-ROD n=10 (%)	32,593 (29.7)	54,729 (49.9)	322 (0.3)	1,036 (0.9)	26 (0.0)	2,933 (2.7)	2,326 (2.1)	15,644 (14.3)	<0.01
	Post-ROD n=8 (%)	25,783 (30.4)	36,793 (43.3)	194 (0.2)	836 (1.0)	22 (0.0)	2,302 (2.7)	1,528 (1.8)	17,441 (20.5)	
Georgia	Pre-ROD n=4 (%)	3,413 (23.8)	9,206 (64.1)	31 (0.2)	32 (0.2)	1 (0.0)	537 (3.7)	207 (1.4)	926 (6.5)	<0.01
	Post-ROD n=3 (%)	3,927 (47.0)	3,138 (37.6)	21 (0.3)	180 (2.2)	33 (0.4)	265 (3.2)	192 (2.3)	597 (7.1)	
Mississippi	Pre-ROD n=3 (%)	2,140 (20.4)	7,706 (73.3)	21 (0.2)	31 (0.3)	1 (0.0)	194 (1.8)	126 (1.2)	294 (2.8)	<0.01
	Post-ROD n=2 (%)	1,862 (55.3)	1,310 (38.9)	10 (0.3)	35 (1.0)	0 (0.0)	34 (1.0)	44 (1.3)	71 (2.1)	
North Carolina	Pre-ROD n=11 (%)	12,032 (43.4)	16,755 (24.4)	177 (0.6)	533 (1.9)	41 (0.1)	2,849 (10.3)	689 (2.5)	4,629 (16.7)	<0.01
	Post-ROD n=8 (%)	11,359 (50.3)	5,687 (25.2)	84 (0.4)	1,292 (5.7)	9 (0.0)	1,172 (5.2)	522 (2.3)	2,470 (10.9)	
South Carolina	Pre-ROD n=3 (%)	5,647 (56.2)	1,349 (13.4)	114 (1.1)	74 (0.7)	4 (0.0)	981 (9.8)	251 (2.5)	1,634 (16.3)	<0.01
	Post-ROD n=3 (%)	339 (35.6)	265 (27.8)	76 (8.0)	8 (0.8)	19 (2.0)	15 (1.6)	221 (23.2)	9 (0.9)	
Tennessee	Pre-ROD n=3 (%)	6,228 (81.3)	649 (8.5)	22 (0.3)	32 (0.4)	3 (0.0)	231 (3.0)	134 (1.7)	365 (4.8)	<0.01
	Post-ROD n=3 (%)	1,388 (72.9)	131 (6.9)	2 (0.1)	4 (0.2)	11 (0.6)	124 (6.5)	22 (1.2)	222 (11.7)	

Table 4: State population breakdown of Income Level Living Within 1-mile radius of select Pre-ROD Superfund Sites and matched Post-ROD Superfund sites in EPA Region 4

		<$15,000	$15,000-$24,9999	$25,000-$34,999	$35,000-$49,999	$50,000-$74,999	$75,000-$99,999	$100,000-$149,999	$150,000-$199,999	$200,0000+	Chi-Square P-Value
Alabama	Pre-ROD n=2 (%)	616 (57.2)	136 (12.6)	100 (9.3)	121 (11.2)	60 (5.6)	16 (1.5)	14 (1.3)	6 (0.6)	8 (0.7)	<0.01
	Post-ROD n=2 (%)	59 (6.3)	58 (6.2)	115 (12.3)	121 (12.9)	191 (20.4)	180 (19.3)	146 (15.6)	43 (4.6)	22 (2.4)	
Florida	Pre-ROD n=10 (%)	10,319 (28.7)	6,380 (17.8)	5,065 (14.1)	5,192 (14.5)	4,709 (13.1)	1,983 (5.5)	1,653 (4.6)	309 (0.9)	288 (0.8)	<0.01
	Post-ROD n=8 (%)	4,851 (31.3)	3,744 (16.4)	2,935 (12.9)	3,997 (17.6)	4,378 (19.2)	1,544 (6.8)	883 (3.9)	234 (1.0)	200 (0.9)	
Georgia	Pre-ROD n=4 (%)	1,787 (37.0)	789 (16.3)	617 (12.8)	715 (14.8)	543 (11.2)	211 (4.4)	114 (2.4)	35 (0.7)	22 (0.5)	<0.01
	Post-ROD n=3 (%)	819 (24.9)	429 (13.0)	448 (13.6)	543 (16.5)	525 (15.9)	284 (8.6)	155 (4.7)	52 (1.6)	37 (1.1)	
Mississippi	Pre-ROD n=3 (%)	1,162 (32.8)	604 (17.1)	442 (12.5)	476 (13.4)	579 (16.4)	119 (3.4)	83 (2.3)	33 (0.9)	43 (1.2)	<0.01
	Post-ROD n=2 (%)	363 (29.4)	178 (14.4)	167 (13.5)	132 (10.7)	143 (11.6)	97 (7.9)	90 (7.3)	22 (1.8)	43 (3.5)	
North Carolina	Pre-ROD n=11 (%)	1,729 (17.8)	1,432 (14.8)	1,503 (15.5)	1,554 (16.0)	1,775 (18.3)	837 (8.6)	600 (6.2)	180 (1.9)	96 (1.0)	<0.01
	Post-ROD n=8 (%)	1,563 (17.7)	1,209 (13.7)	997 (11.3)	1,146 (13.0)	1,706 (19.4)	902 (10.2)	702 (8.0)	282 (3.2)	302 (3.4)	
South Carolina	Pre-ROD n=3 (%)	964 (28.3)	761 (22.3)	411 (12.1)	498 (14.6)	483 (14.2)	154 (4.5)	92 (2.7)	21 (0.6)	22 (0.6)	<0.01
	Post-ROD n=3 (%)	369 (42.8)	242 (28.1)	68 (7.9)	35 (4.1)	78 (9.0)	51 (5.9)	10 (1.2)	9 (1.0)	0 (0.0)	
Tennessee	Pre-ROD n=3 (%)	869 (28.9)	515 (17.2)	472 (15.7)	375 (12.5)	403 (13.4)	177 (5.9)	131 (4.4)	25 (0.8)	35 (1.2)	<0.01
	Post-ROD n=3 (%)	867 (47.1)	717 (38.9)	66 (3.6)	38 (2.1)	55 (3.0)	33 (1.8)	25 (1.4)	19 (1.0)	22 (1.2)	

4.3 Comparing Race/Ethnicity and Income for Pre-ROD and Post-ROD Superfund Sites in Alabama

A chi-square analysis was done comparing race/ethnicity populations in Alabama presented in Table 3. The Pearson Chi-Square value calculated was 2,638.709 with df=7. The p-value was determined to be <0.01, which is considered statistically significant difference in income level for the population surrounding these sites.

A chi-square analysis was comparing income for the populations in Alabama presented in Table 4. The Pearson Chi-Square value calculated was 835.141 with df=8. The p-value was determined to be <0.01, which is considered statistically significant difference in income level for the population surrounding these sites. The proportions for race/ethnicity are presented in Figure 4 and the proportions for income are presented in Figure 5.

Figure 4: Race/Ethnicity Proportions for Selected Pre-ROD and Post-ROD Superfund Sites in Alabama

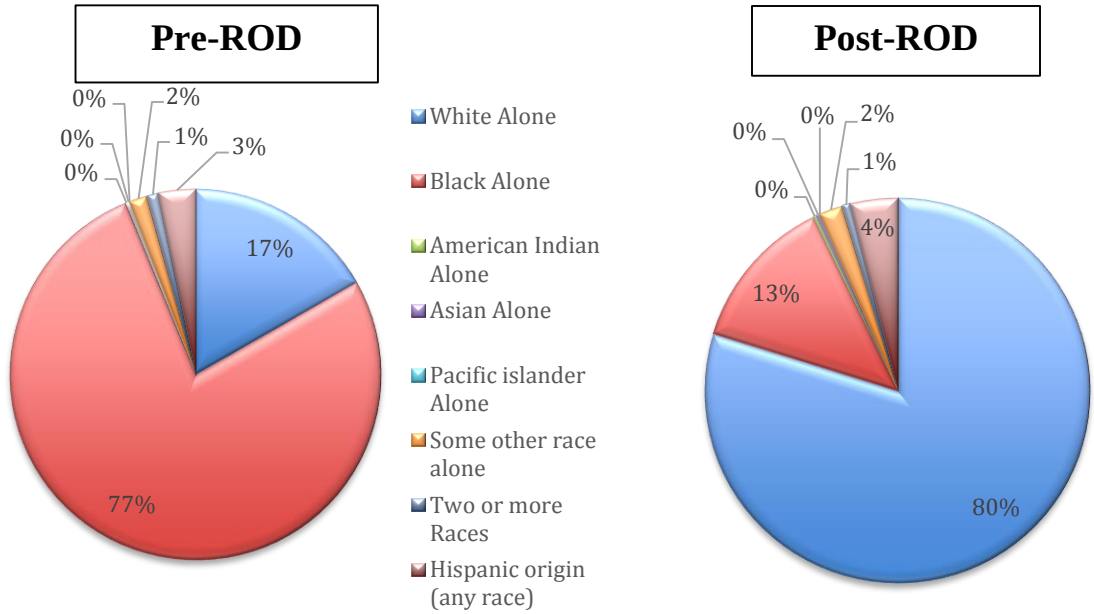
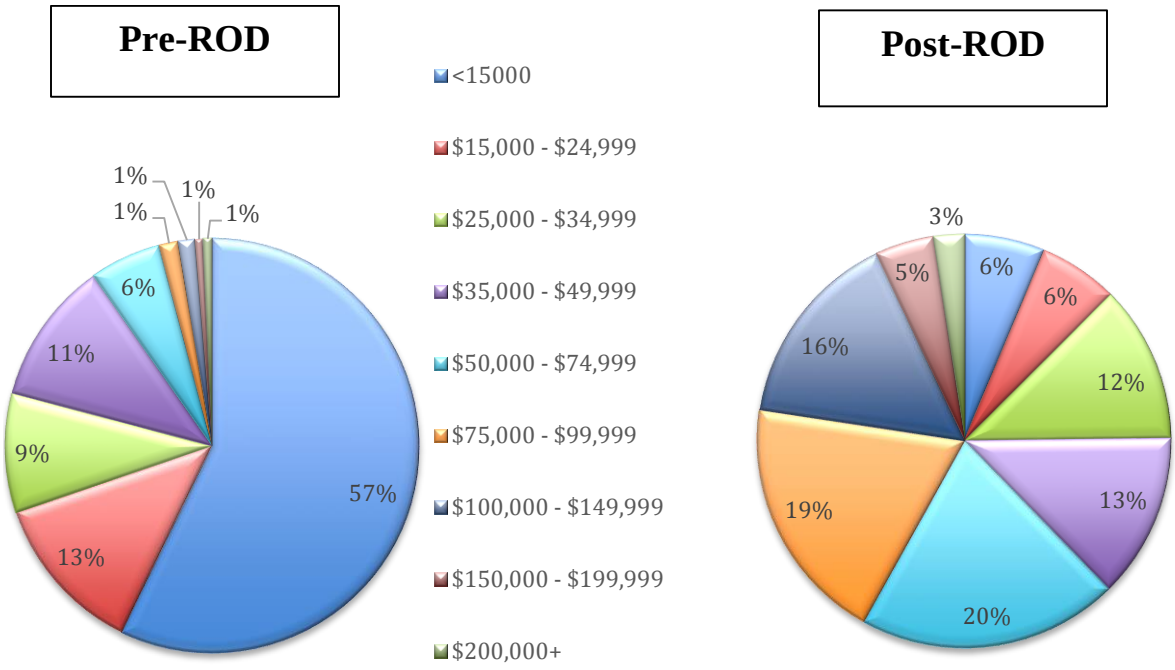


Figure 5: Income Level Proportions for Selected Pre-ROD and Post-ROD Superfund Sites in Alabama



Comparing the race/ethnicity proportions between the Pre-ROD sites and the Post-ROD sites, there is a vast difference between the populations. In the Pre-ROD sites, 77% of the population is black whereas only 13% of the population living within close proximity to the Post-ROD sites in Alabama is black. There is also a large difference with the white proportion with 80% of the population being white close to the Post-ROD sites in comparison to only 17% of the population being white near the Pre-ROD sites. The visual representation of the data shows that a larger proportion of minorities live closer to the Pre-ROD sites in comparison to the Post-ROD sites. Unlike the pie charts that compare all of the Post-ROD sites to the Pre-ROD sites in the study, these charts show much more of a difference between the race/ethnicity proportions.

A similar pattern is found when analyzing the proportions for the income levels. Figure 5 reveals that 57% of the population living within close proximity to the Pre-ROD sites makes less

than $15,000 whereas only 6% of the population within close proximity to the Post-ROD sites fall into that same income level. In fact, 79% of the Pre-ROD population in Alabama makes less than $35,000 in comparison to 37% for the Post-ROD sites. Overall, the chi-square for the race/ethnicity and the income levels is statistically significant, which rejects the null hypothesis that the populations for the Pre-ROD sites and Post-ROD sites are the same.

4.4 Comparing Race/Ethnicity and Income for Selected Superfund Sites in Florida in EPA Region 4

A chi-square analysis was done comparing the race/ethnicity for the selected populations in Florida using the data presented in Table 3. The Pearson Chi-Square value calculated was 1,588.299 with df=7. The p-value was determined to be <0.01, which is considered statistically significant difference in income level for the population surrounding these sites.

A chi-square analysis was done comparing selected populations based on the income data presented in Table 4. The Pearson Chi-Square value calculated was 807.352 with df=8. The p-value was determined to be <0.01, which is considered statistically significant difference in income level for the population surrounding these sites. The race/ethnicity proportions are graphically presented in Figure 6 and the income proportions are visually presented in Figure 7.

Figure 6: Race/Ethnicity Percentages for Selected Pre-ROD and Post-ROD Superfund Sites in Florida

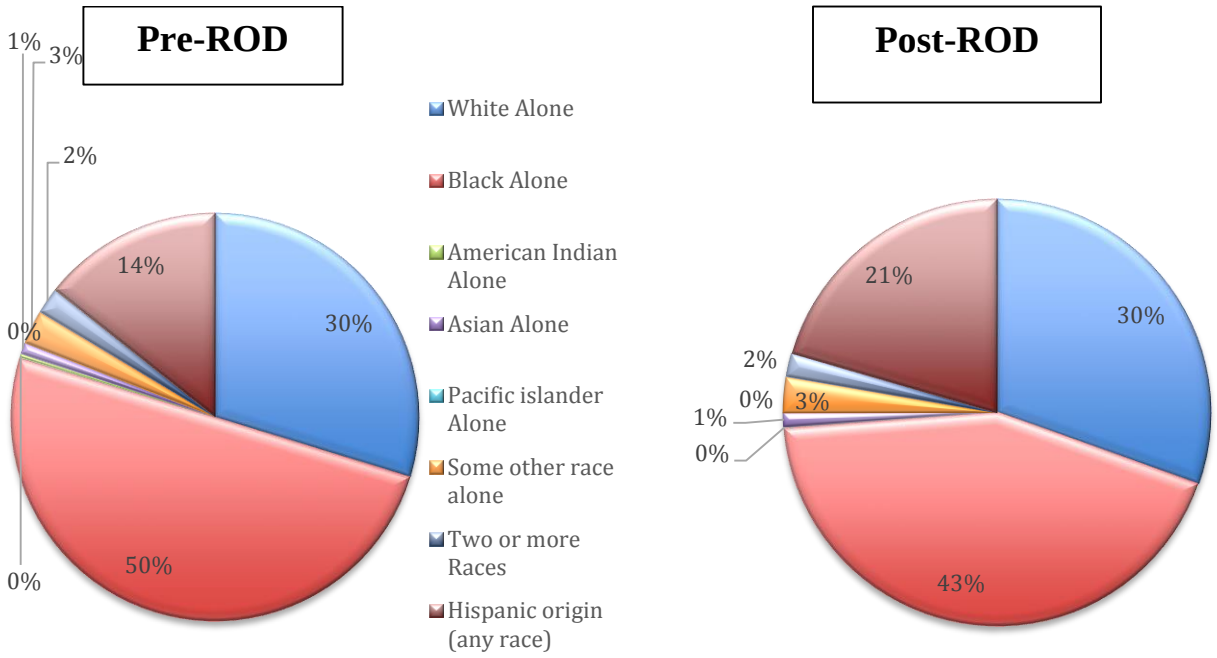
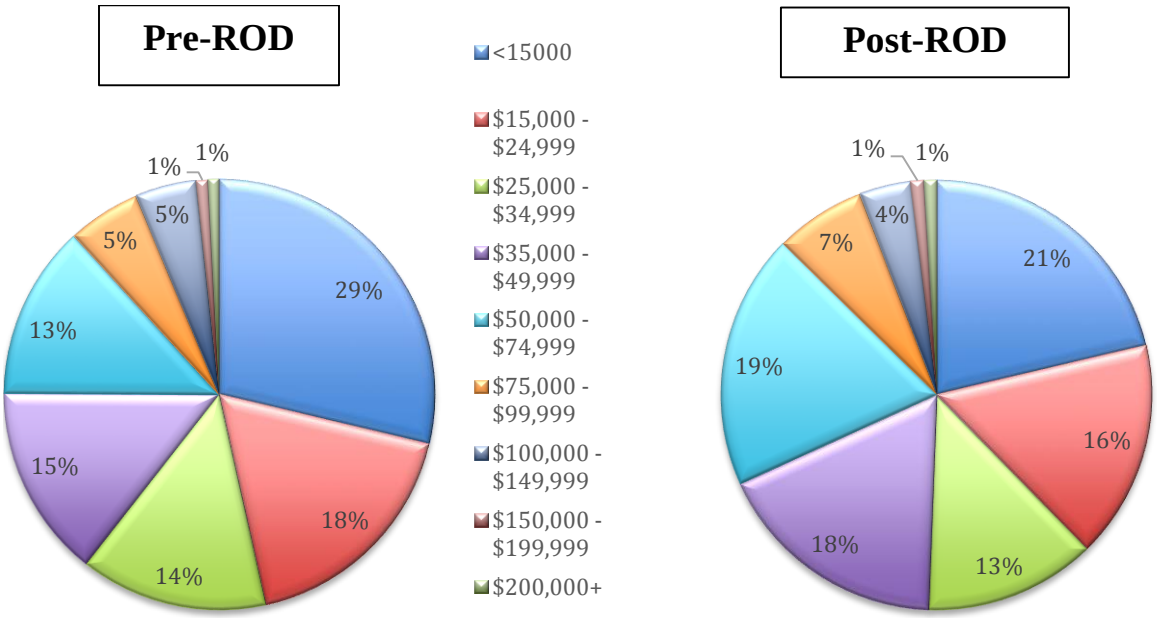


Figure 7: Income Level Percentages for
Selected Pre-ROD and Post-Rod Superfund Sites in Florida



The figures depicting the proportions in Florida show a different scenario than in Alabama. Looking at the race/ethnicity, the exact same proportion of whites is found for both the Pre-ROD sites and Post-ROD sites. While there is a slightly larger proportion of blacks living closer to the selected Pre-ROD sites in comparison to the selected Post-ROD sites in Florida, overall the proportion of minorities for both sites is the same.

For the Superfund sites in Florida, the population closer to the selected Pre-ROD sites were poorer in comparison to the population living in close proximity to the Post-ROD sites. This is exemplified by 29% of the Pre-ROD population having an income lower than $15,000 in comparison to 21% for the Post-ROD sites. Overall, a slightly larger proportion in of the Pre-ROD population makes less than $35,000 than the Post-ROD sites.

4.5 Comparing Race/Ethnicity and Income for Selected Superfund Sites in Georgia

A chi-square analysis was done comparing the Pre-ROD and Post-ROD Superfund site populations regarding race/ethnicity in Georgia. The Pearson Chi-Square value calculated was 1,862.698 with df=7. The p-value was determined to be <0.01, which is considered statistically significant difference in income level for the population surrounding these sites.

A chi-square analysis was also done comparing Pre-ROD and Post-ROD Superfund site populations in terms of income for the state of Georgia. The Pearson Chi-Square value calculated was 257.760 with df=8. The p-value was determined to be <0.01, which is considered statistically significant difference in income level for the population surrounding these sites. The proportions for race/ethnicity is graphically presented in Figure 8 and the income proportions are graphically presented in Figure 9.

Figure 8: Race/Ethnicity Percentages for Selected Pre-ROD and Post-ROD Superfund Sites in Georgia

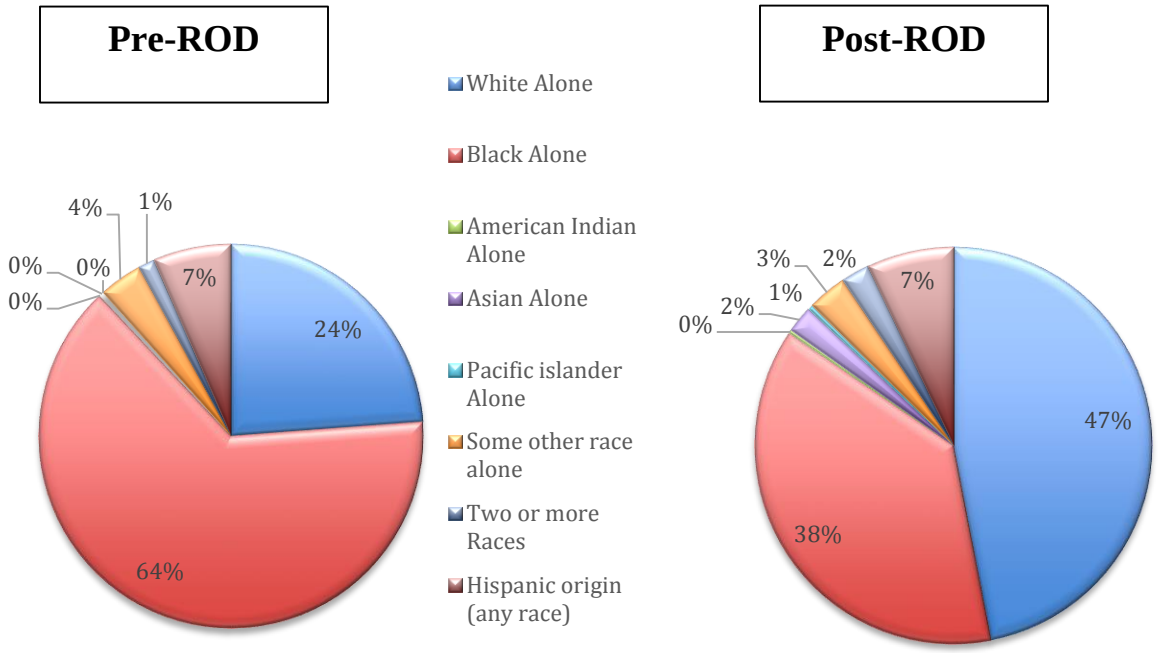
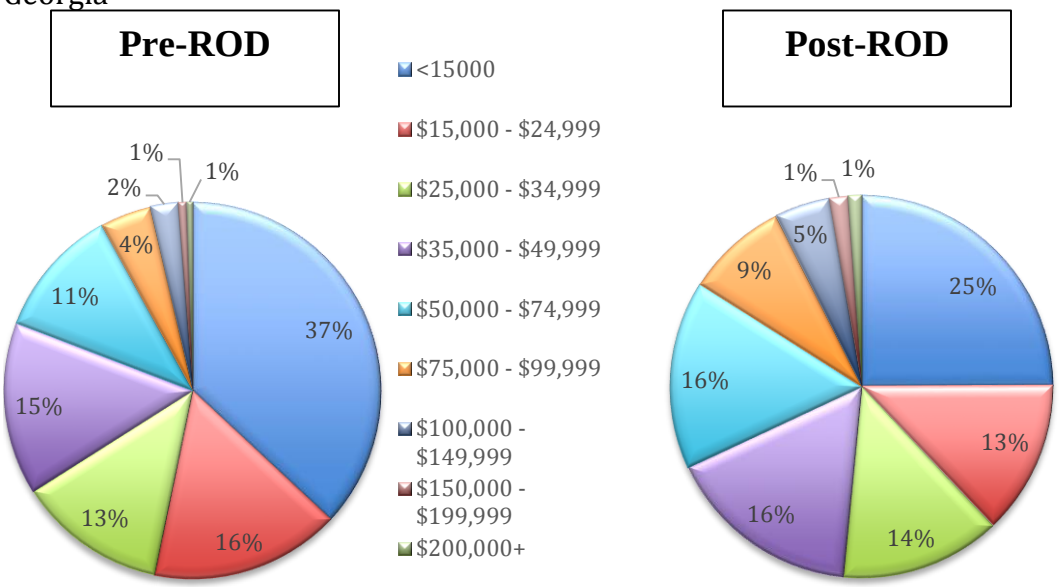


Figure 9: Income Level Percentages for Selected Pre-ROD and Post-ROD Superfund Sites in Georgia



For the selected Superfund sites in Georgia, the race/ethnicity proportions are quite different when comparing the Pre-ROD sites to the Post-ROD sites where a larger proportion of minorities live closer to the Pre-ROD sites in comparison to the Post-ROD sites. Out of the Pre-ROD population, 24% are white whereas 47% of the population near the Post-ROD sites is white. The population in close proximity to the selected Pre-ROD sites in Georgia is almost ¾ minority whereas a little over ½ is considered a minority for the Post-ROD sites.

The population living within close proximity to the selected Pre-ROD sites is also poorer than that near the Post-ROD sites. The proportion with an income less than $15,000 for the Pre-ROD sites is 37% in comparison to only 25% near the Post-ROD sites. A little over 50% have an income less than $35,000 for the selected Post-ROD sites in Georgia in comparison to a little less than 75% for the Pre-ROD population.

4.6 Comparing Race/Ethnicity and Income for Selected Superfund Sites in Mississippi

A chi-square analysis was done comparing the Pre-ROD and Post-ROD Superfund site populations based on race/ethnicity. The Pearson Chi-Square value calculated was 1,591.588 with df=7. The p-value was determined to be <0.01, which is considered statistically significant difference in income level for the population surrounding these sites.

A chi-square analysis was also done comparing the Pre-ROD and Post-ROD Superfund sites in Mississippi based on income. The Pearson Chi-Square value calculated was 161.836 with df=8. The p-value was determined to be <0.01, which is considered statistically significant difference in income level for the population surrounding these sites. The proportions are graphically presented for race/ethnicity in Figure 10 and for income in Figure 11.

Figure 10: Race/Ethnicity Percentages for Selected Pre-ROD Superfund Sites in Mississippi

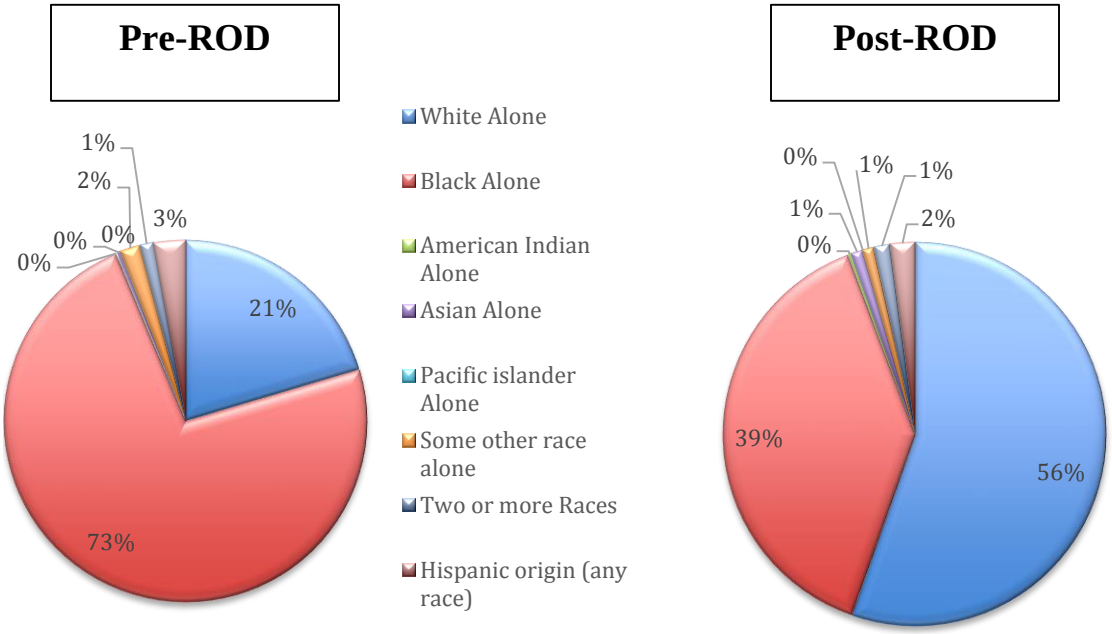
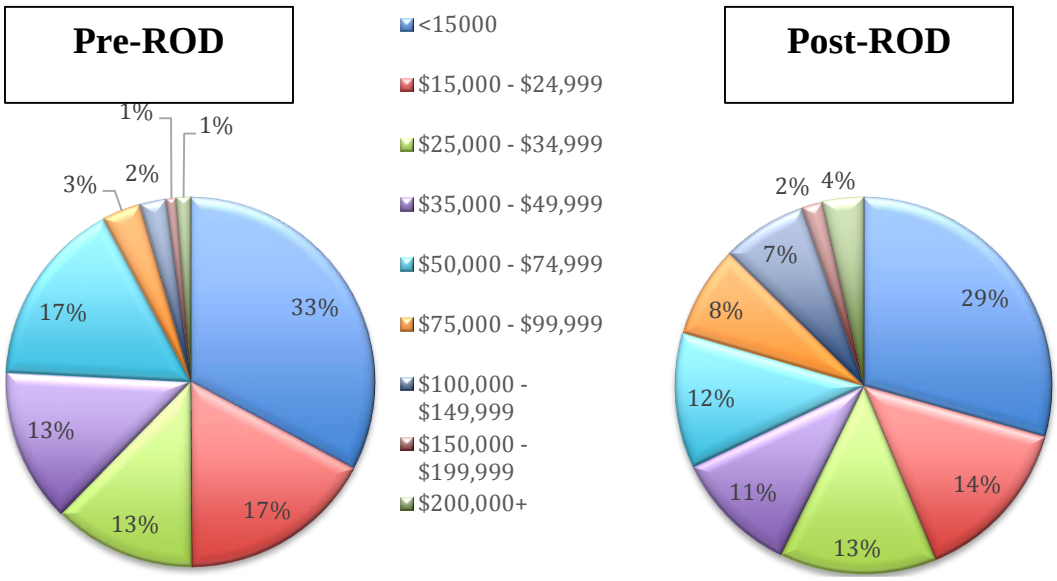


Figure 11: Income Level Percentages for Selected Pre-ROD and Post-ROD Superfund Sites in Mississippi



The race/ethnicity proportion breakdown for the selected Superfund sites in Mississippi showed a larger proportion of minorities in the Pre-ROD superfund sites in comparison to the Post-ROD sites. In the Pre-ROD sites, 73% of the population was black in comparison to only 39% in the Post-ROD sites. The trend is similar when looking at the proportion of whites in the population with 21% of the Pre-ROD population being white in comparison to 56% in the Post-ROD population. The other minorities make up similar proportions in both the Pre-ROD sites and Post-ROD sites.

While the race/ethnicity proportions are different between the Pre-ROD sites and Post-ROD sites, the income proportions between the two categories are somewhat similar in Mississippi. In the selected Pre-ROD sites, 33% of the population has an income less than $15,000. In comparison, 29% of the population in the selected Post-ROD sites has an income less than $15,000. This is a similar scenario when comparing the proportions making $15,000-$24,999. In the Pre-ROD sites, 17% fall into this category whereas 14% in the Post-ROD sites fall into this category. Overall, there is a slightly higher proportion of poorer people living within close proximity to the selected Pre-ROD sites in Mississippi, however the difference is not as vast as seen with the race/ethnicity proportions.

4.7 Comparing Race/Ethnicity and Income for Selected Superfund Sites in North Carolina

A chi-square analysis was done comparing the Pre-ROD and Post-ROD Superfund site populations in North Carolina in terms of race/ethnicity. The Pearson Chi-Square value calculated was 1,3541.218 with df=7. The p-value was determined to be <0.01, which is considered statistically significant difference in income level for the population surrounding these sites.

A chi-square analysis was also done comparing Pre-ROD and Post-ROD Superfund site populations in North Carolina in terms of income. The Pearson Chi-Square value calculated was 289.421 with df=8. The p-value was determined to be <0.01, which is considered statistically significant difference in income level for the population surrounding these sites. The proportions for the race/ethnicity data are graphically presented in Figure 12 and the income proportions are presented in Figure 13.

Figure 12: Race/Ethnicity Percentages for Selected Pre-ROD and Post-ROD Superfund Sites in North Carolina

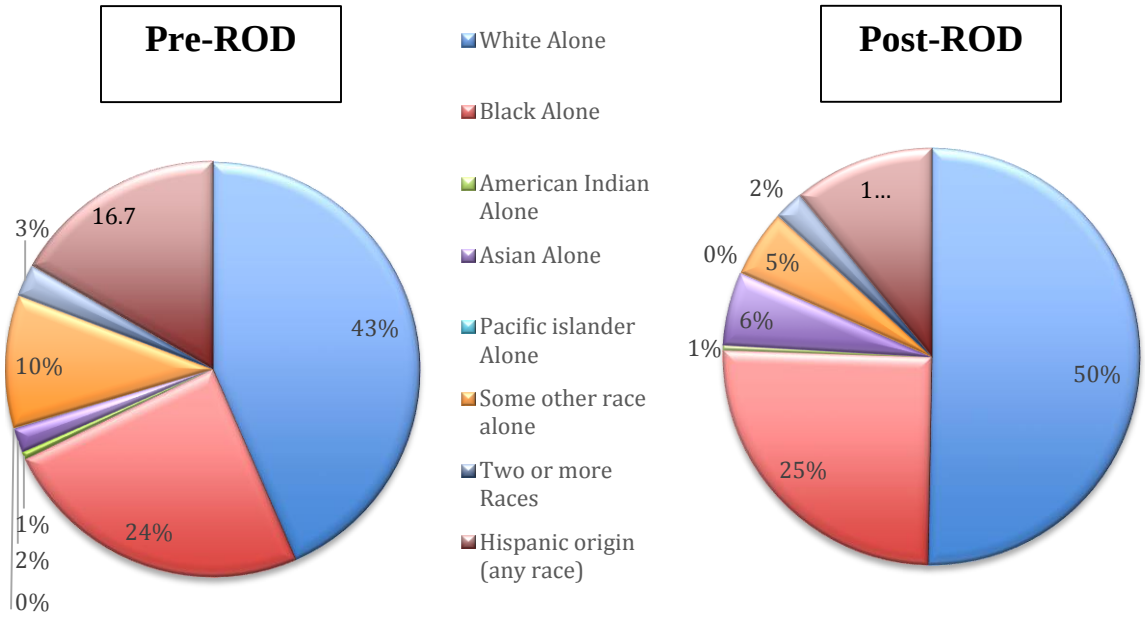


Figure 13: Income Level Percentages for Selected Pre-ROD and Post-ROD Superfund Sites in North Carolina

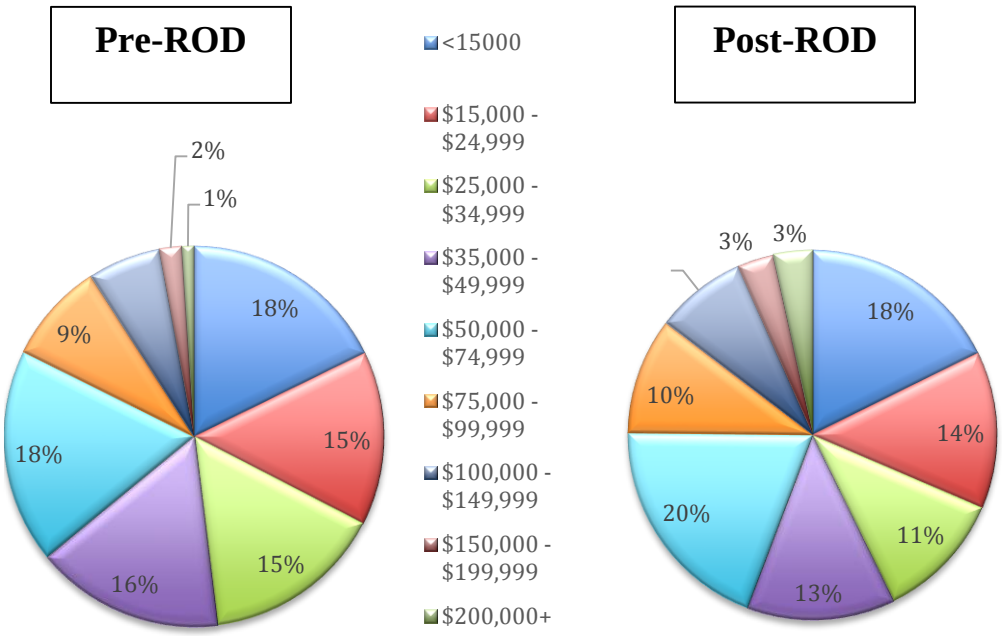


Figure 12 and 13 reveal that in the Pre-ROD Superfund sites in North Carolina, minorities make up over half of the population for the study, whereas minorities make up 50% of the population for the Post-ROD Superfund sites. Similar proportions are observed for blacks in both with 24% in Pre-ROD sites and 25% in Post-ROD sites. There is a higher proportion of Hispanics in the Pre-ROD superfund sites in comparison to the Post-ROD sites with 17% in the Pre-ROD sites and 11% in the Post-ROD sites. Although there is a higher proportion of minorities observed in the Pre-ROD sites in comparison to the Post-ROD Superfund sites, the difference is not as large as observed in other states.

A similar situation is observed when analyzing the income levels for the North Carolina population in the study. In the selected Pre-ROD sites for North Carolina, 18% of the population has an income <$15,000 and the same proportion is observed in the Post-ROD sites. Similarly, the proportion for people that have an income between $15,000 and %24,999 is 15% in the Pre-

R0D sites in comparison to 14% in the Post-ROD sites. While there are differences in income levels for the two categories of Superfund sites, the differences do not appear to be as grand as observed in other states.

4.8 Comparing Race/Ethnicity and Income for Selected Superfund Sites in South Carolina

A chi-square analysis was done comparing the Pre-ROD and Post-ROD Superfund site populations in South Carolina based on race/ethnicity. The Pearson Chi-Square value calculated was 1,657.757 with df=7. The p-value was determined to be <0.01, which is considered statistically significant difference in income level for the population surrounding these sites.

A chi-square analysis was also done comparing the Pre-ROD sites and Post-ROD Superfund site populations based on income levels. The Pearson Chi-Square value calculated was 158.853 with df=8. The p-value was determined to be <0.01, which is considered statistically significant difference in income level for the population surrounding these sites. Figure 14 graphically presents the proportions for race/ethnicity data for South Carolina and Figure 15 graphically presents income proportions.

Figure 14: Race/Ethnicity Percentages for Selected Pre-ROD and Post-ROD Superfund Sites in South Carolina

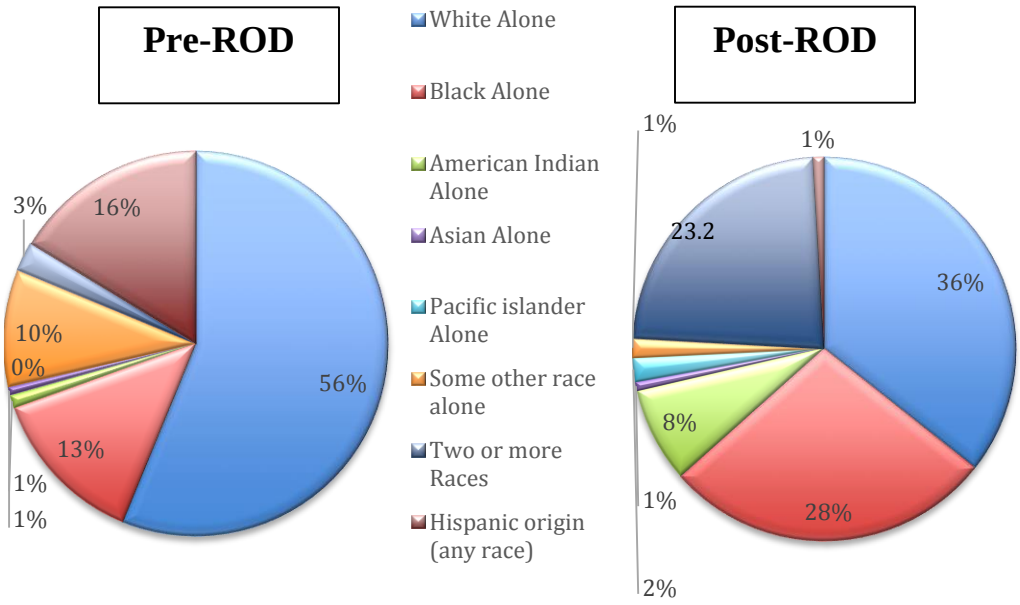
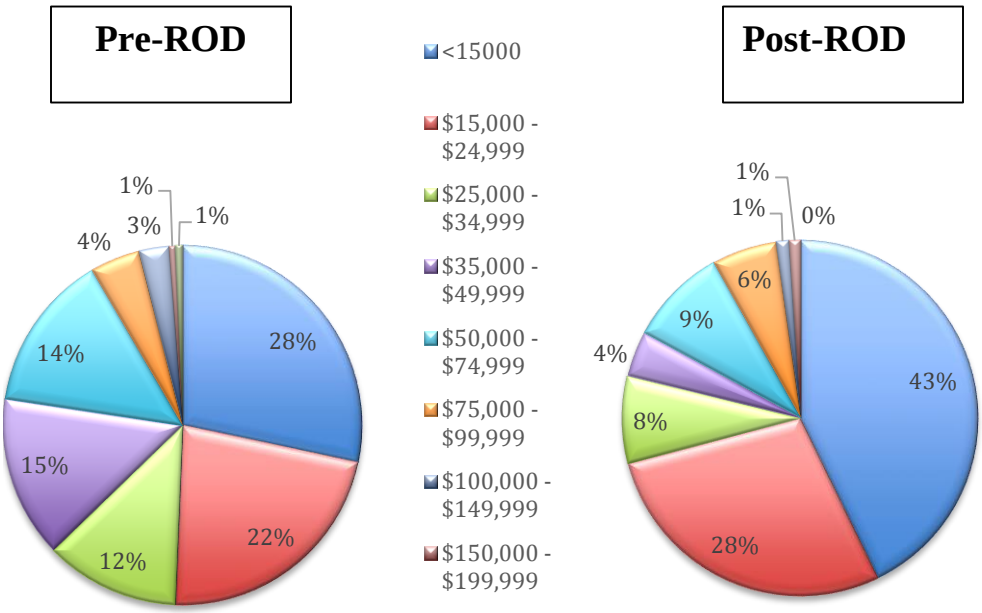


Figure 15: Income Level Percentages for Selected Pre-ROD and Post-ROD Superfund Sites in South Carolina



The results in South Carolina for the Race/Ethnicity proportions are opposite than expected. In the selected Pre-ROD Superfund sites in the state, 56% of the population is white

whereas only 36% is white in the selected Post-ROD Superfund sites. With that said, a larger proportion of minorities is actually observed in the Post-ROD Superfund sites rather than in the Pre-ROD Superfund sites. Overall 64% of the population is minorities in the Post-ROD Superfund sites whereas only 44% of the Pre-ROD Superfund site population is a minority. This is opposite of what has been seen in other states.

The results for the income levels observed for the population in South Carolina for the study is also opposite of what was predicted. There is a much larger proportion of lower income people observed in the Post-ROD Superfund sites in comparison to the Pre-ROD sites. In the Pre-ROD sites, only 28% of the population has an income <$15,000 but in the Post-ROD sites, 43% of the population has an income <$15,000. Almost 75% of the population in the Post-ROD sites has an income less than $25,000 whereas only 50% of the population in the Pre-ROD sites has an income less than $25,000. These results were opposite of what was predicted and what was observed in other states in EPA Region 4.

4.9 Comparing Race/Ethnicity and Income for Selected Superfund Sites in Tennessee

A chi-square analysis was done comparing the Pre-ROD and Post-ROD Superfund site populations in Tennessee based on race/ethnicity. The Pearson Chi-Square value calculated was 223.969 with df=7. The p-value was determined to be <0.01, which is considered statistically significant difference in income level for the population surrounding these sites.

A chi-square analysis was also done comparing the populations based on income. The Pearson Chi-Square value calculated was 822.867 with df=8. . The p-value was determined to be <0.01, which is considered statistically significant difference in income level for the population surrounding these sites. Figure 16 graphically presents the proportions for the race/ethnicity data in Tennessee and Figure 17 graphically presents the income proportions.

Figure 16: Race/Ethnicity Percentages for Selected Pre-ROD and Post-ROD Superfund Sites in Tennessee

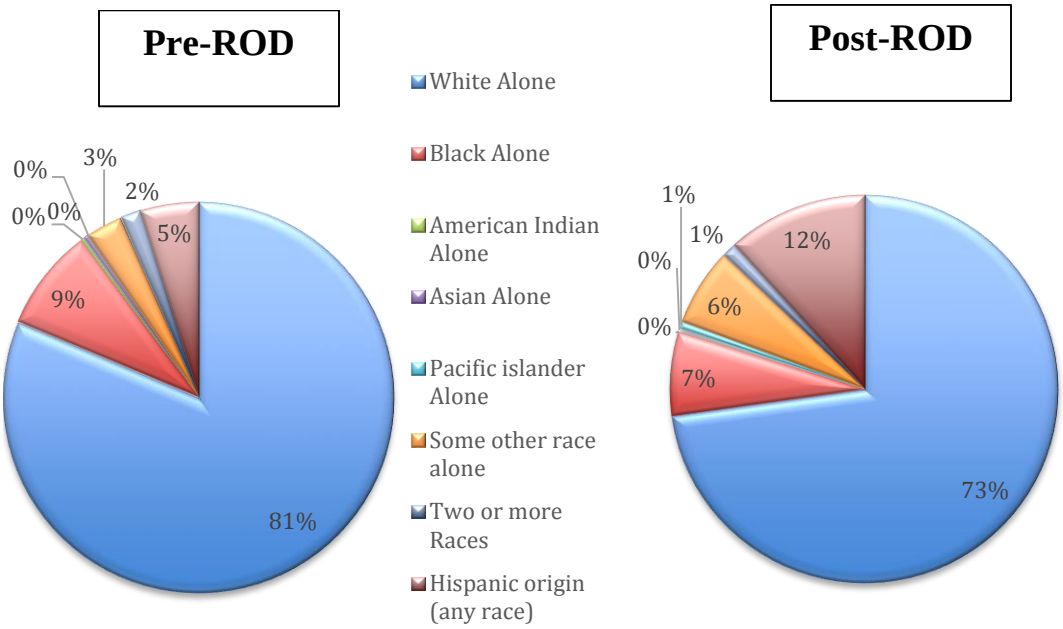
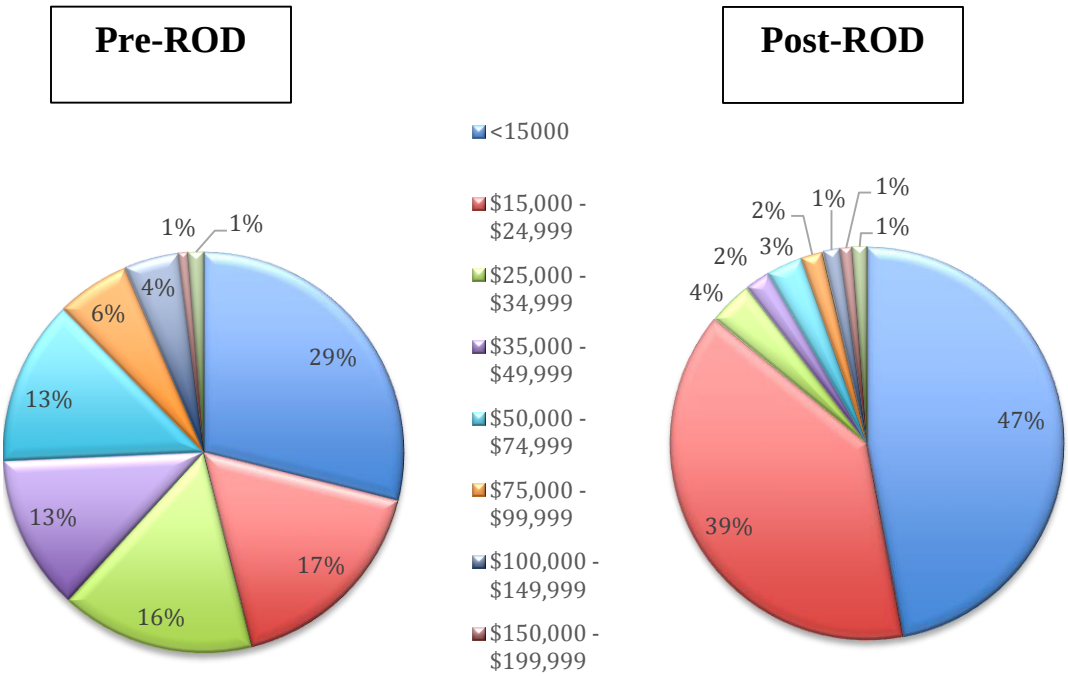


Figure 17: Income Level Percentages for Selected Pre-ROD and Post-ROD Superfund Sites in Tennessee



The results for the race/ethnicity in Tennessee were also slightly different than expected. In the Pre-ROD Superfund sites, 81% of the population is white whereas 73% are white in the Post-ROD sites. This shows that a slightly larger proportion of minorities is observed in the Post-ROD sites in comparison to the Pre-ROD sites. In the selected Post-ROD sites, 27% are minorities whereas in the Pre-ROD sites, 19% of the population is a minority. Like the results observed in South Carolina, these are opposite of what was predicted. Although there is a higher proportion of minorities observed in the Post-ROD sites, the populations do not seem to be as different as what was observed in South Carolina.

The results portrayed in Figure 17 for the income proportions also show different results than what were expected with a larger proportion of lower income people living in close proximity to the Post-ROD Superfund sites in comparison to the Pre-ROD sites. Over 80% of the population living in close proximity to the Post-ROD Superfund sites in Tennessee have an income less than $25,000, but only 46% of the population living within close proximity to the Pre-ROD sites make less than $25,000. There is such a major difference between the income levels observed for the two categories of Superfund sites in Tennessee with the population living in close proximity to the Post-ROD Superfund sites being of a lower income level in comparison to the population living within close proximity to the Pre-ROD sites.

Chapter V

DISCUSSION AND CONCLUSION

5.1 Discussion

The results of the study presented mixed findings on differences between the populations living within close proximity to Pre-ROD Superfund sites and Post-ROD Superfund sites. The chi-square analyses suggest that the populations are different; however, due to the limitations of the differences are difficult to interpret.. In the total population of the study, the selected Pre-ROD Superfund sites did have a slightly larger proportion of minorities in comparison to the Post-ROD Superfund sites. The Pre-ROD Superfund sites had a slightly larger proportion of the population that had lower income (<$15,000) per year. These results suggest that the populations may be different surrounding Superfund sites. Similar findings have been documented in other studies ("Toxic Waste and Race", 1987; Bullard et al., 2008). For example, in "Toxic Waste and Race", (1987) they found that there were a disproportionate number of minorities living in communities with hazardous waste sites. Bullard et al., 2008 found similar results finding socioeconomic and racial disparities in the nation's hazardous waste sites and their locations.

Comparing the Pre-ROD and Post-ROD Superfund site populations for each State provided additional information on how these differences may be distributed across states in the EPA Region 4. For example, the largest differences in race were found for the comparison made for the (4) sites from Alabama where almost $4/5^{th}$ of those situated near Pre-ROD sites were black while $4/5^{th}$ of those situated near Post-ROD sites were white. Whether this is the result of unjust practices or an artifact of the small number of sites compared is difficult to know. However, Bullard et al., (2008) listed Alabama as one of the top ten states with some of the

largest differences in racial composition of host and non-host areas for treatment storage and disposal facility location.

In this analysis, similar differences for race were also observed for the sites compared in Georgia and Mississippi. While these states also had smaller numbers of observations, Bullard et al., (2008) also highlighted Georgia as a state that has an unequal distribution in host and non-host areas for waste facilities. States that demonstrated smaller differences in racial composition between the selected sites were Florida and North Carolina. These states had the largest numbers of sites included for comparison, which may have had an impact on the results.

South Carolina and Tennessee presented results that were opposite from the aforementioned states. The Post-ROD Superfund sites had a higher proportion of minorities than the Pre-ROD sites. It is hard to determine whether this is due to Environmental Justice actions or simply due to the small amount of sites in the study, but Bullard et. al., (2008) listed Tennessee as one of the top ten states with some of the largest differences in racial composition of host and non-host areas for treatment storage and disposal facility location, thus making the findings of this study different than what is found in other studies. Similarly, "Toxic Waste and Race", (1987) found that two cities in Tennessee, Memphis and Chattanooga, had the highest percentage of blacks living in communities with uncontrolled waste sites. The findings in this study does not support previous findings for Tennessee, however based on the small amount of Superfund sites used for the Tennessee analysis, the results cannot conclude that there is Environmental Justice in this state. The differences seen in this study may also be a result of different operational definitions of "uncontrolled hazardous waste sites". In Bullard et. al., (2008), South Carolina still presented a higher ratio of minorities living in communities with hazardous waste sites, but it was not one of the highest ratios, such as observed in Tennessee or Alabama. The

findings in this study presents data that is not expected based on previous studies, however the reasoning behind this is undeterminable.

The study does highlight that there are differences seen between the Pre-ROD and Post-ROD sites, however, the differences seen in this study may not be completely due to a lack of environmental justice. Rather than there being a lack in environmental justice, it may be possible that the EPA is in fact addressing EJ issues and are better able to identify sites that have disproportionate minority and low-income populations thus are more likely placed on the NPL than in the past. If this were the case, similar results would be seen as what was shown in the study. Differentiating whether a higher minority and lower income population is based on lack of environmental justice practices or if the EPA is in fact addressing these issues is difficult to determine based on the methodology used in the study.

5.2 Study Limitations

A major limitation of the study is that there is a large temporal difference between the Post-ROD sites and Pre-ROD sites selected for this study. For example, a large number of Post-ROD sites in this study were placed on the NPL prior to the 1990s. In comparison the Pre-ROD sites are newly listed on the NPL. One matched pair that exemplifies this limitation comes from Florida. The Pre-ROD site, Arkla Terra Property, was placed on the NPL in 2009 versus the matched Post-ROD site, BMI Textron, was placed on the NPL in 1990. The ROD is anticipated in 2015 for Arkla Terra and BMI Textron was removed from the NPL in 2002. With such a large gap in when these sites have any remediation action, it is hard to convey if there are differences solely using 2010 census data. One way the time disparity could have impacted the results includes the fact that the population for the Post-ROD site could have changed simply based on time lapse rather than cleanup efforts. If this was the case, the results in this study

would not be reflective of the remediation status but rather of the time difference. It is hard to draw any sort of conclusions from the study because of the large time disparity between the Pre-ROD sites and Post-ROD sites.

Another limitation of the study is that there are a limited amount of Post-ROD Superfund sites within a reasonable distance to the Pre-ROD sites, therefore some of the Post-ROD sites were matched multiple times, making the population overall smaller for the Post-ROD sites in comparison to the Pre-ROD sites. It would have been better to be able to match each site instead of duplicating them, but the amount of sites that have were considered Post-ROD limits this possibility, especially when trying to identify them based on location.

The data could have been affected based on using the Community Analyst tool from ArcGIS that only contained projected population information for the year 2013 that categorized the population of interest into different income levels. In comparison, 2010 census data was included for the breakdown of race/ethnicity for the population in the study, but this data was not available for the breakdown of income level. Comparing the populations from Table 3 and 4, it is apparent that the populations for the income analysis is lower in comparison to the race analysis. This could have impacted the results because the lower sample size in the income analysis could have limited the findings.

Stratifying the data by state also presented limitations in the study. When comparing the Post-ROD Superfund sites to the Post-ROD Superfund sites for each state, the amount per state varied. Some states such as North Carolina and Florida had more sites included in the study versus other states such as Alabama and Mississippi that had fewer sites included in the study. This could have impacted the results. Mississippi, Alabama, and Georgia presented some of the

larger racial differences, but this could have been based on the small sample size. In comparison, North Carolina and Florida had more sites included in the analysis and they presented smaller differences in race. Based on these findings, the results may have been more reflective of the sample size rather than attributable to environmental justice differences.

Another major limitation of the study was using a 1-mile radius around the latitude and longitudinal coordinates for the sites of interest. It was assumed that using the 1-mile radius around the coordinates would include the surrounding communities of the Superfund sites. However, some of the sites were much larger than others, and looking at the data collected, not as many people were included in these sites. Because of limiting it to a 1-mile radius from the listed coordinates, the full picture of the community may not have been fully captured. This could have limited the results with some of the sites being less represented in comparison to other sites-thus swaying the results in the favor of the more represented sites. Other limitations include information that was provided regarding the status of the ROD. The data that was used for the study may have been outdated and so the most up-to-date information may not have been included in this study. In other studies such as Bullard et. al., (2008), communities were compared based on whether a hazardous waste site was hosted in the community versus a community where a hazardous waste site was not hosted. Rather than doing a comparison of the Pre-ROD and Post-ROD sites, it might have been better to look at communities with Superfund sites and compare them to communities without a Superfund site.

In this study, a hazardous waste site was defined as one that was listed on the NPL, however this definition may not have accurately defined a hazardous waste site. For example, if it is determined that the relative risk is high for a site, it may be cleaned up through emergency response rather than through listing it on the NPL. This would constitute as a hazardous waste

site, however these types of sites were not included in this study. Sites may also not be listed on the NPL if the state does not agree to pay their part of the cleanup process. These two scenarios both constitute 'hazardous waste sites' that would not be listed on the NPL, so limiting the scope of this project to only sites listed on the NPL overall limited the sites that were included in the project.

The study also was limited by the assumption that the communities surrounding the Pre-ROD sites were exposed to the contamination of the site. For comparison purposes, it was assumed that the Pre-ROD populations were exposed whereas the Post-ROD populations did not have exposure to contamination. The goal of this study was to determine the potential for environmental exposures, however this may not be the case due to the fact that in some cases, even before the ROD is put into place, immediate clean-up action takes place. If immediate clean up does take place, the Pre-ROD population may not have a hazardous environmental exposure that was assumed in the study.

Lastly, limiting the Superfund sites in the study is a study limitation. It would have been better to include all Superfund sites across EPA Region 4, however with the amount of sites in the region, it would have been difficult to do so for this study purpose. Including all of the sites would have given a better picture of the populations living within close proximity to the Superfund sites to help draw a better conclusion.

5.3 Recommendations

Results from this study raises other questions that should be explored in future studies. In particular, are the findings here only found in Region 4 or would a similar analysis find differences in other EPA Regions. Looking at another EPA region and doing a similar study to

explore population proportions living within close proximity to sites that have been Post-ROD and comparing it to those that have not would help to see if that region also sees variance amongst the states, especially since Environmental Justice efforts are largely implemented at the regional level in the EPA.

As mentioned in the study limitations, there is a large time difference between the Post-ROD sites and the Pre-ROD sites as far as when they were listed on the NPL and therefore addressed by the EPA. One way to have a more accurate comparison of the populations would be to look at the census data around the time when the site was listed on the NPL. Looking at this information would help to determine if the population demographic was similar prior to the site being cleaned up or if there was a demographic shift after completing the clean-up for the site.

The study did show that there were differences in the populations living within close proximity to the Pre-ROD sites and Post-ROD sites, with some states having a larger difference than others. Although these results were depicted from the study, it is hard to draw conclusions about the origin of these differences and what might be driving the differences. Future studies should limit cofounders to try to determine why there are differences between the two types of sites.

Future studies also need to take place that include all Superfund sites across EPA Region 4 and to expand the geographic scope of the community analysis. t Comparing the totals at 1, 3 and 5 mile radius might help to further clarify the populations living near each site. Including different distances to the Superfund sites would help to increase the population in the study.

Lastly, it is important to have an operational definition of what constitutes an environmental hazardous waste site. In this study, as mentioned in the limitations, a hazardous waste site was defined as a site that was placed on the NPL, however this definition excludes sites that are cleaned-up with other measures than federal funding. Looking at previous studies, there is no definitive definition of what constitutes a site to be considered a hazardous waste site. Development of an operational definition that could be applied consistently across studies would help in future comparisons.

5.4 Conclusion

Based on the results, it appears that there is more of a difference between populations for the Pre-ROD and Post-ROD sites when comparing sites by states rather than comparing them overall in EPA Region 4. Alabama and Mississippi seem to have the larger difference with a larger minority population as well as a poorer population living in close proximity to the Pre-ROD superfund sites in comparison to the Post-ROD sites. However variables that could contribute substantially but were not within the scope of the analysis, (such as time) it is difficult to identify whether or not substantial disparity exists. The study helps to provide the stepping-stone for future studies that can further explore the idea of Environmental Justice and the role of Superfund.

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